IS 8783-1 (1995): Winding wires for submersible motors, Part 1: Conductor data [ETD 33: Winding Wire]

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भारतीय मानक

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भाग 1 चालक संबंधी आंकड़े

(पहला पुनरीक्षण)

Indian Standard

WINDING WIRES FOR SUBMERSIBLE MOTORS — SPECIFICATION

PART 1 CONDUCTOR DATA

(First Revision)

First Reprint AUGUST 1998

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Price Group 3

FOREWORD

This Indian Standard (Part 1) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Winding Wires Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was originally published in 1978 covering PVC insulated winding wires for submersible motors for 85°C operation. Two other standards on winding wires for submersible motors, namely, IS 10051 : 1981 'Specification for PVC insulated winding wires for submersible motors for 105°C operation' and IS 12788 : 1989 'Specification for PVC insulated winding wires overcoated with nylon for submersible motors' have also been in vogue.

In the recent past there has been demand from the industry to make comprehensive revision of the existing standards on winding wires for submersible motors and also to include other types of insulation which are being extensively used in manufacture of winding wires for submersible motors. In view of this the new series of winding wire standards for submersible motors is being brought out as follows:

IS 8783	Winding wires for submersible motors — Specification
(Part 1) : 1995	Conductor data
(Part 2) : 1995	Materials for dielectric and jacket
(Part 3) : 1995	Methods of tests
(Part 4/Sec 1) : 1995	Specification for individual wires, Section 1 HR PVC insulated winding wires
(Part 4/Sec 2) : 1995	Specification for individual wires, Section 2 Crosslinked polyethylene insulated and polyamide jacketed wires
(Part 4/Sec 3) : 1995	Specification for individual wire, Section 3 Polyester and polypropylene insulated wires

With the publication of these standards the requirements of PVC insulated wires will be covered in Part 4/Sec 1 of this series, and two new types of insulation, namely, XLPE insulated and polyester and polypropylene insulated wires have also been covered in this series.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

AMENDMENT NO. 1 FEBRUARY 2000
TO
IS 8783 (PART 1) : 1995 WINDING WIRES FOR SUBMERSIBLE MOTORS — SPECIFICATION
PART 1 CONDUCTOR DATA

(First Revision)

(*Page* 2, *clause* **8**) — Substitute the following for the existing:

'**8 PACKING** — The conductor shall be wound on spools/reels/coils as per IS 482 : 1981, packed and labelled.'

[*Page* 2, *clauses* **9.1**, *line* 2, **9.1**(d), *and* **9.1**(g)] — Substitute the words 'spool/reel/coil' *for* 'spool/reel'.

(*Page* 6, *Table* 4, *col* 3 *and* 4) — Delete the word 'mm' given under col 3 and 4.

(ETD 33)

Reprography Unit, BIS, New Delhi, India

Indian Standard

WINDING WIRES FOR SUBMERSIBLE MOTORS — SPECIFICATION

PART 1 CONDUCTOR DATA

(First Revision)

1 SCOPE

This standard (Part 1) covers the requirements of high conductivity annealed round and stranded copper conductors used for winding wires for submersible motors irrespective of types of insulation. The range of size include solid round conductor dia 0·4 mm to 5·0 mm and stranded conductor area 3·58 mm² to 25·65 mm².

2 REFERENCES

The following Indian Standards are necessary adjuncts to this Standard:

IS No.	*Title*
482 : 1981	Reels for covered round electrical winding wires (*third revision*)
1885 (Part 32) : 1993	Electrotechnical vocabulary : Part 32 Electric cables (*first revision*)
8783 (Part 3) : 1995	Winding wires for submersible motors : Part 3 Methods of tests (*first revision*)

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 1885 (Part 32) : 1993, and the following shall apply.

3.2 Tolerance

The permissible deviation (magnitude) of an actual reading from that prescribed.

4 MATERIAL

4.1 Conductor

The conductor shall be made from high conductivity annealed copper having the properties given in **4.1.1**.

4.1.1 *Physical Constants for Annealed Copper*

4.1.1.1 *Coefficient of linear expansion*

The coefficient of linear expansion of annealed copper over a temperature range of 0 to 150°C shall be taken as 17×10^{-6}/°C

4.1.1.2 *Density*

The density of annealed copper at a temperature of 20°C shall be taken as 8·89 g/cm³.

4.1.1.3 *Resistance*

The resistance at 20°C of a conductor of annealed copper of one metre in length and of a uniform cross-sectional area of one square millimetre shall be taken as 0·017 241 ohm. The method of calculation of conductor resistance is given in Annex A. The temperature correction factors are given in Table 3.

4.1.1.4 *Constant mass temperature coefficient of resistance*

At a temperature of 20°C the constant mass temperature coefficient of resistance of annealed copper measured between two potential points rigidly fixed to the conductor, the metal being allowed to expand freely, shall be taken as 0·003 93/°C.

NOTE — For any temperature to above 0°C the temperature coefficient of resistance is $\frac{1}{234{\cdot}45 + t_o}$

4.1.2 *Form of Conductor*

The conductors shall be circular solid or stranded as per the specific requirement. The conductor shall be clean bright reasonably uniform in size and shape. smooth and free from slivers, spills, cracks and other harmful defects.

4.1.3 *Joints in Conductor*

4.1.3.1 *Solid conductors*

No joints shall be made in finished solid conductor.

4.1.3.2 *Stranded conductors*

Joints shall be permitted in the individual strands of which the conductor is formed, but no joint shall be within 300 mm of any other joint within the same layer. The joints shall be made by resistance butt welding, fusion welding, cold

pressure welding, electric welding, gas welding, brazing or silver soldering. The joints in individual strand shall be such that no deformity is observed in finished stranded conductor.

5 CONDUCTOR COMPOSITION

5.1 Round Conductor

5.1.1 The conductor shall consist of single strand of bright annealed plain copper in accordance with Table 1.

5.1.2 The conductor shall be of solid circular cross-section.

5.2 Stranded Conductor

5.2.1 The conductor shall consist of bright annealed plain copper strands in accordance with Table 2.

5.2.2 The strands in the conductor shall have the same nominal diameter before stranding.

5.2.3 The number of strands in the conductor shall be in accordance with Table 2.

5.3 Tolerance on the Nominal Wire Diameter

The tolerance on the nominal wire diameter shall be $\pm$ 1 percent of basic size.

6 DETAILS OF TESTS

Tests	*For Requirements, Ref to*	*For Test Method, Ref to*
Dimensions	Tables 1 and 2	IS 8783 (Part 3)
Annealing test (elongation)	Tables 1 and 2	do do
Resistance test	Tables 1 and 2	
Visual examination	**4.1.2** of this specification.	

7 IDENTIFICATION

The manufacturers identification shall be provided on labels. The label shall contain the name of the manufacturer and trade name, if any.

8 PACKING

The conductor shall either be wound on spools/reels as per IS 482 : 1981 packed and labelled.

9 MARKING

9.1 The conductor shall carry following information labelled on spool/reel:

a) Reference to Indian Standard, for example, IS 8783 (Part 1);

b) Manufacturer's name, brand name or trade-mark;

c) Size of conductor/nominal cross-sectional area;

d) Number of lengths on spool/reel (if more than one);

e) Approximate gross mass;

f) Year of manufacture; and

g) Direction of rotation of spool/reel.

NOTE —The requirements of packing and marking are not applicable when the processing of the conductor forms part of the manufacturing of complete winding wire.

9.2 BIS Certification Marking

The product may also be marked with the Standard Mark.

9.2.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Table 1 Conductor Data — Round Solid Conductor

(*Clause* 5.1.1)

Cross-Sectional Area (Nominal) mm²	Diameter of Conductor (Nominal) mm	Elongation (*Min*) Percent	Conductor Resistance at 20°C (*Max*) ohm/km
(1)	(2)	(3)	(4)
0·126	0·40	24	140·0
0·159	0·45	25	112·0
0·196	0·50	25	89·6
0·238	0·55	26	74·7
0·283	0·60	26	62·2
0·332	0·65	28	53·5
0·385	0·70	28	45·7
0·442	0·75	28	40·2
0·502	0·80	28	35·0
0·568	0·85	29	31·3
0·636	0·90	29	27·6
0·709	0·95	30	25·1
0·785	1·0	30	22·4
0·950	1·1	30	18·5
1·130	1·2	31	15·5
1·330	1·3	32	13·2
1·540	1·4	32	11·4
1·770	1·5	32	9·95
2·010	1·6	32	8·75
2·270	1·7	32	7·75
2·540	1·8	32	6·91
2·840	1·9	32	6·20
3·140	2·0	33	5·60
3·460	2·1	33	5·08
3·800	2·2	33	4·63
4·150	2·3	33	4·23
4·520	2·4	33	3·89
4·910	2·5	33	3·58
5·310	2·6	34	3·31
5·730	2·7	34	3·07
6·160	2·8	34	2·86
6·610	2·9	34	2·66
7·070	3·0	34	2·49
7·550	3·1	35	2·33
8·040	3·2	35	2·19
8·550	3·3	35	2·06
9·080	3·4	35	1·94
9·620	3·5	35	1·83
10·180	3·6	36	1·73
10·750	3·7	36	1·64
11·340	3·8	36	1·55
11·950	3·9	36	1·47
12·570	4·0	37	1.40
13·200	4·1	37	1·33
13·850	4·2	38	1·27
15·210	4·4	38	1·16
16·620	4·6	38	1·06
18·100	4·8	39	0·972
19·640	5·0	40	0·896

NOTE — The copper wire samples taken from finished insulated winding wire shall exhibit 95 percent value of the elongation given in col 3 above.

Table 2 Conductor Data — Stranded Conductor

(*Clauses* 5.2.1 *and* 5.2.3)

Conductor Cross-Sectional Area (Nominal) mm^2	Number of Strands	Diameter of Strands Nominal mm	Elongation Before Stranding Percent	Conductor Diameter (Nominal) mm	Conductor Resistance at 20°C *Max* ohm/km
(1)	(2)	(3)	(4)	(5)	(6)
3·58	19	0·49	25	2·45	5·10
4·03	19	0·52	25	2·60	4·53
4·50	19	0·55	26	2·75	4·05
5·00	19	0·58	26	2·90	3·64
5·55	19	0·61	26	3·05	3·23
6·11	19	0·64	26	3·20	2·93
6·90	19	0·68	28	3·40	2·60
7·95	19	0·73	28	3·65	2·26
9·08	19	0·78	28	3·90	1·98
10·00	19	0 82	28	4·10	1·79
12·09	19	0·90	29	4·50	1·48
13·18	19	0·94	29	4·70	1·36
14·04	19	0·97	30	4·85	1·28
14·92	19	1·00	30	5·00	1·20
16·00	19	1·04	30	5·20	1·11
18·06	19	1·10	30	5·50	0·993
20·08	19	1·16	31	5·80	0·893
21·30	27	1·00	30	6·15	0·846
25·65	27	1·10	30	6·80	0·699

NOTE — The copper wire samples taken from finished insulated winding wire shall exhibit 95 percent of the elongation given in col 4 above.

The test, however, shall be conducted on the central wire.

Table 3 Temperature Correction Factors for Conductor Resistance to Correct the Measured Resistance at t°C to 20°C

(*Clause* 4.1.1 3)

Temperature t°C	Multiplier Constant	Reciprocal Constant	Temperature t°C	Multiplier Constant	Reciprocal Constant
(1)	(2)	(3)	(1)	(2)	(3)
10	1·040 9	0·960 7	29	0·965 8	1·035 4
10·5	1·038 8	0·962 7	29·5	0·964 0	1·037 3
11	1·036 7	0·964 6	30	0·962 2	1·039 3
11·5	1·034 6	0·966 6	30·5	0·960 4	1·041 3
12	1·032 5	0·968 6	31	0·958 5	1·043 2
12·5	1·030 4	0·970 5	31·5	0·956 8	1·045 2
13	1·028 3	0·972 5	32	0·955 0	1·047 2
13·5	1·026 2	0·974 5	32·5	0·953 2	1·049 1
14	1·024 1	0·978 4	33	0·951 4	1·051 1
14·5	1·022 1	0 978 4	33·5	0·949 6	1·053 1
15	1·020 0	0·980 4	34	0·947 8	1·055 0
15·5	1·018 0	0·982 3	34·5	0 946 1	1·057 0
16	1·016 0	0·984 3	35	0·944 3	1·059 0
16·5	1·013 9	0·986 2	35·5	0·942 6	1·060 9
17	1·011 9	0·988 2	36	0·940 8	1·062 9
17·5	1·009 9	0·990 2	36·5	0·939 1	1·064 8
18	1·007 9	0 992 1	37	0·937 4	1·066 8
18·5	1·005 9	0·994 1	37·5	0·935 7	1·068 7
19	1·003 9	0·996 1	38	0·933 9	1·070 8
19·5	1·002 0	0·998 0	38·5	0·932 2	1·072 7
20	1·000 0	1·000 0	39	0·930 5	1·074 7
20·5	0·998 0	1·002 0	39·5	0·928 8	1·076 6
21	0·996 1	1·003 9	40	0·927 1	1·078 6
21·5	0·994 1	1·005 9	40·5	0·925 4	1·080 6
22	0·992 2	1·007 9	41	0·923 8	1·082 5
22·5	0·990 3	1·009 8	41·5	0·922 1	1·084 5
23	0·988 3	1·011 8	42	0·920 4	1·086 5
23·5	0·986 4	1·013 8	42·5	0·918 8	1·088 4
24	0·984 5	1·015 7	43	0·917 1	1·090 4
24·5	0·982 6	1·017 7	43·5	0·915 5	1·092 3
25	0·980 7	1·019 7	44	0·913 3	1·094 9
25·5	0·978 8	1·021 6	44·5	0·912 2	1·096 3
26	0·977 0	1·023 6	45	0·910 5	1·098 3
26·5	0·975 1	1·025 5	45·5	0·908 9	1·100 2
27	0·973 2	1·027 5	46	0·907 3	1·102 2
27·5	0·971 4	1·029 5	46·5	0·905 7	1·104 1
28	0·969 5	1·031 4	47	0·904 1	1·106 1
28·5	0·967 7	1·033 4	47·5	0·902 5	1·108 0

NOTE — Given the resistance of a wire t°C, the resistance at 20°C, is calculated by multiplying the resistance at t°C by the multiplier constant given in the above table. Conversely given the resistance at 20°C the corresponding resistance at t°C is calculated by multiplying the resistance at 20°C by the reciprocal constant for t°C also given in the table above.

ANNEX A

(*Clause* 4.1.1.3)

FORMULA FROM WHICH RESISTANCE IS CALCULATED

The resistance value specified have been calculated from the formula:

$$R = \frac{4\rho}{n\pi d^2} k_1 k_2$$

where

R = resistance at 20°C in ohms/km;

ρ = standard resistivity of the metal at 20°C in absolute ohm, mm²/km, that is, 17·241 for annealed copper.

n = number of wires in the conductor;

d = nominal diameter of the wires in the conductor in millimetres;

k_1 = a factor depending on the diameter of the wire in the conductor, the value of this factor is given in Table 4.

k = a factor depending on the way in which the conductor is formed the value of this factor is as given below:

	Factor k_2
— For solid conductor	1.00
— For stranded conductor where nominal strand diameter:	
a) exceeds 0·6 mm	1.62
b) does not exceed 0·6 mm	1.64

Table 4 Factor k_1

Maximum Diameter of Wires in Conductor		Solid Conductor	Stranded Conductor
Over	Up to and Including		
(1)	(2)	(3)	(4)
mm	mm	mm	mm
0·31	4·5	1·03	1·02
4·50	—	—	—

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'.

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